Performance Objectives And Instructional Cues	OUTLINE AND PRESENTATION

XVII.B OPERATION OF PATROL VEHICLE

INTRODUCTION

Vehicle Dynamics

Instructional Goals

1. This course will provide the student with knowledge of vehicle operation factors and the dynamics behind vehicle behavior when forces are applied.

2. This course will provide the student with instruction in proven operational principles and techniques of performance driving.

Objectives

1. Understand principles of vehicle dynamics and their relationship to the operation of the motor vehicle.

2. Understand and explain the two types of vehicle control.

3. Understand limits of adhesion for performance driving.

4. Understand differences between sliding and rolling friction.

5. Understand the effects of speed and braking during emergency operation.

6. Understand perception and reaction and its effect on braking.

7. Understand weight transfer and G force and how it relates to vehicle control and accident avoidance.

8. Understand purpose for stability in vehicles and other aspects of mechanical equilibrium.

9. Understand the effect centripetal and centrifugal force has on performance driving.

10. Understand that a key element to emergency operation is proper apexing and corner entry technique.

11. Understand how understeer or oversteer occurs and the proper countermeasures.

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Time Allocation: 2.5 hours

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LO1

I. Vehicle Dynamics E.V.O.

Vehicle dynamics is nothing more than a description of the physical forces acting on the vehicle. If a vehicle receives an input that is contrary to the laws of motion, the vehicle will have a negative response.

LO2
OHD13

A. Vehicle Control

Maintaining vehicle control is critical in emergency vehicle operation. At no time is it acceptable to be out of control.

1. Loss of control

   a) Losing control – limits of the driver are exceeded; this situation is salvageable if driver applies proper technique to regain control

   b) Out of control – Limits of the vehicle are exceeded. This situation is not salvageable, the driver cannot regain control.

LO3

B. Limits of adhesion

1. Limit of adhesion is the maximum performance of a vehicle as it relates to the tires four-rubber contact patches.

   a) Four contact points the size of your hand.

   b) Contact point creates traction to go, stop and turn the vehicle.

2. Factors that limit adhesion are:

   a) Vertical force (weight on tire)

   b) Tire design (radials keep more tire in contact with roadway).

   c) Road surface and grade (dry or snow packed/level or on hill).

   d) Turning force (radius of turn).

   e) Speed (more speed, more force applied).

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LO4

OHD 14
(Stages of Friction)

C. Rolling Friction vs. Sliding Friction

1. Sliding Friction

   a) Wheels locked not turning.

   b) Must be turning to steer vehicle.

   c) During emergency braking a vehicle will travel farther with brakes locked and sliding than a vehicle with the brakes applied up to point of lockup.

2. Rolling Friction

   a) Wheel rolling not locked.

   b) Rolling tires allow vehicle to turn and stop more efficiently.

   c) You can eliminate rolling friction by locking the brakes or by being too aggressive with your steering.

3. Shuffle/slow hands steering and late apex corner entry are designed to maximize rolling friction.

LO5

D. Braking and speed control

1. One of the most dangerous driving elements the police officer must understand is the relationship of speed to stopping distance.

   a) The faster you drive the more room you need to stop your vehicle.

   b) When speed is increased by a factor of two (doubles) your stopping distance increases by a factor of four (quadruples).

2. Speed is relative to the existing conditions.

   a) Most would agree 100 mph is too fast.

   b) Most would also agree 20 mph is also fast when

traveling down a snow packed hill towards a busy intersection.

3. According to National Safety Council statistics excessive speed is the single largest cause of accidents. These figures reflect speed too fast for conditions and not necessarily the posted speed limit.

4. As a vehicle moves down the road the driver is managing time and space.

   a) Measured with a speedometer.

   b) Speed is measured in miles per hour (not realistic).

   c) Accidents occur in seconds not hours.

   d) Accidents don't occur in miles, occur in feet and inches.

5. We as drivers should think in terms of feet per second rather than miles per hour.

   a) Easy conversion – Take mph and divide in half, add to original mph – equals approximate feet per second.

   b) At 60 mph a ½ second slower reaction time equals 22 feet.

   c) At 40 mph you divert your attention to the pretty girl on the sidewalk for 1 second. That equals 60 feet.

   d) At 100 mph 1 second equals 150 feet or half a football field.

6. Today's vehicles are engineered so well and have so many creature comforts it's easy to lose sense of speed.

LO6

E. Perception/Reaction

1. It is impossible to discuss speed and braking without understanding perception/reaction.

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2. Today's drivers seem to be focused on everything except driving.

   a) Cellular phones

   b) Stereo/CD Player/Tape Player

   c) Passengers/kids

   d) Stressors – other drivers, work schedule, relationships.

3. Today's police officers seem to have more and more distractions as well.

   a) Radio (multiple channels/scanner)

   b) Mobile data terminals

   c) Cellular phones

   d) Radar/cameras

   e) Job related activities (traffic violations, emergency response, building checks, suspicious persons, etc.)

4. Stopping distances are made up of two components.

   a) Reaction time

   b) Braking time/distance

OHD 15
(Stopping Distance)

5. Reaction time is the time it takes us to mentally process the information and react to a situation.

OHD 16
(Stopping Distance Graph)

   a) The accepted national average reaction time is ¾ second.

6. Braking time/distance is based on many variables.

   a) Type of vehicle

   b) Type of braking system

   c) Roadway surface conditions

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7. Perception/reaction can be the deciding factor in determining whether a driver avoids or fails to avoid a collision.

LO7

F. Weight transfer/G forces

1. Weight transfer is determined by the direction in which the vehicle is turned or forced.

    a) Weight transfer causes

        1) Too much steering and too much braking

        2) Too much steering and too much power

    b) Result in either case is too much weight transfer

        1) Too much pressure on tire patch equals out of control.

2. G Force or (G.) is a term used to measure maximum acceleration, deceleration and lateral acceleration a vehicle can handle.

    a) Any movement produces force, a (G.) is a means of measuring that force.

    b) Force is generated by a combination of steering and speed.

    c) As the steering wheel is moved a force pushes on the vehicles center of gravity.

    d) If the force is greater than what the vehicle can accept it will go out of control.

    e) All vehicles are limited in the amount of force they can accept.

    f) The most important thing to remember about G Force is that very small changes in speed can make very big changes in vehicle dynamics.

    g) Speedometer is linear device which progresses in

equal steps.

1) 20 to 40 mph is 20 mph

2) 40 to 60 mph is 20 mph

h) Force exerted on a vehicle is not linear.

1) When a driver increases speed by a factor of two (doubles) the force increases by a factor of four (quadruples).

i) Lateral G. Force created in a turn is based upon both the vehicle's weight and the degree or sharpness of the turn.

1) If we say 2800 lbs of force is being exerted on the vehicle it doesn't' tell us much, we have to know the weight of the vehicle as well.

OHD 17
(Example G-Force Loads at 10 mph increments)

2) 4000 lbs of force exerted on a 5000 lb vehicle is ok.

3) 4000 lbs of force exerted on a 2500 lb vehicle is not ok.

OHD 18
(Example G-Force ratings)

4) It is easier to say the vehicle can absorb 0.7 G's.

(a) With a 5000 lb vehicle, 0.7 G's means it can absorb 3500 lbs of force before becoming unstable.

(b) If it is a 2000 lb vehicle the same 0.7 G's means it can absorb 1400 lbs. before becoming unstable.

LO8

G. Mechanical Equilibrium

1. There are three forms of mechanical equilibrium.

a) Stable

b) Unstable

c) Neutral

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2. The automobile is engineered and constructed to insure stable mechanical equilibrium.

3. Manufacturers place heavy vehicle structural members and components as low on the vehicle as possible to increase stability and lower the center of gravity.

4. All vehicles on the road are considered stable, just some are more stable than others. The more stable a vehicle is, the higher the center of gravity must be raised to turn it over.

LO9

OHD 19
(Illustration of Centripetal and Centrifugal force)

H. Centripetal and Centrifugal Force

1. Centripetal force means “center seeking” or the force towards center of the circle.

   a) Tires represent centripetal force in that without them we would continue in a straight line instead of turning.

2. Centrifugal force means “center fleeing’ or the force towards outside of circle.

   a) The weight and mass of the vehicle represent the centrifugal force of the vehicle.

3. There are many ways to exceed the limit of these forces.

   a) Going into a turn too fast. The mass of the vehicle exceeds the ability of the tires to hold vehicle on road.

   b) Locking the brakes in a turn – the moment the brakes locked and the vehicle lost rolling traction the vehicle will be unable to turn.

   c) Turning steering wheel too much in a panic turn – once the front wheels are turned to the degree that front wheels are sideways you have eliminated rolling traction. It’s essentially like the front brakes are locked.

LO10

I. Corner Entry/Apexing

1. Most loss of control accidents occur while cornering.

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2. Things to consider prior to entering a curve or a turn.

   a) Distance to turn.

   b) Speed of vehicle

   c) Sharpness of curve

   d) Bank of curve

   e) Road surface

   f) Load type and condition of vehicle

   g) Visibility through curve/turn

   h) Escape route

3. There are three basic elements to a turn or curve.

   a) Approach and entry to a turn

   b) Apexing the turn or negotiating the arc

   c) Exiting the turn

4. When we use the term 100% of the roadway we mean only the 100% available to you. If you cannot see around a curve then 100% becomes only your lane.

5. The type of turning technique we recommend and instruct is called “Late Apex”.

   a) The apex is the point where your vehicle will come closest to the inside portion of the roadway in a turn.

   b) More specifically it is the point where you can begin to steer your vehicle out of the corner.

   c) Up to now you have probably been using an early apex; for the remainder of this course you will be using the “Late Apex” technique.

OHD 20
(Illustration of horse-shoe turn.)

6. Disadvantages of early apex turning technique are:

   a) Must brake sooner prior to curve, lose the ability

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to accelerate deeper into turn.

OHD 21-22 (Illustration of 90° turn; Early & Late Apex)

b) It takes the vehicle longer coming out of the turn to get straight; therefore you cannot accelerate as soon.

c) The centrifugal force on backside of turn forces you to the outside and eliminates your ability to avoid possible obstructions on a blind turn.

d) Another negative aspect of early apex turning is trail over. When turning the rear tires don't track in the same line as the front tires, they take a shorter path or radius through the turn. This is known as the trail over effect.

1) If you notice most of the cones struck on the track are struck with the rear tire, which is an indicator of early apex.

7. Advantages of "Late Apex" steering

a) "Late Apex" steering works 100% of the time.

b) You can accelerate deeper into turns before applying brakes.

c) You can accelerate sooner coming out of turns, therefore you gain advantage coming in and going out of turn.

d) On exiting (backside) the turn you can have the ability to navigate your vehicle either right or left.

e) "Late Apex" causes vehicle to take a wider path therefore eliminating trail over.

OHD 23 (Illustration of Egress turn.)

8. We advocate "Late Apex" steering as working 100% of the time; however it should be noted that under certain road conditions there are times when the early apex technique will net a quicker time.

a) Egress turns

Egress turns are generally turns of 90% of less where conditions allow the driver clear visibility of all traffic and sufficient roadway to make an earlier apex turn than usual.

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OHD 24
(Illustration of Ess turn.)

b) Ess turns

Ess turns are one or a series of small radius turns. The key to efficiently driving ess turns is to make small changes in acceleration and braking and remember the shortest distance between two points is a straight line.

LO11

K. Understeer and Oversteer

1. The amount and speed the steering wheel is turned has a direct effect on how a vehicle will react when cornering.

2. If the controls are used improperly in a cornering situation it will generally causes the vehicle to understeer or oversteer.

3. Understeer occurs when cornering and the front tires lose traction with surface and skid outwards from curve.

OHD 25
(Understeer IllustratLOn)

a) Two basic reasons for understeer

1) Road conditions/weather – Rain, snow, ice, gravel, dirt, etc.

2) Attempts to turn too fast, front tires skid and exceed limit of adhesion.

3) Too much or too soon on accelerator while in the turn. When gas is applied rear wheels drive vehicle forward, which is its natural direction. You are attempting to turn the vehicle at the same time you are applying throttle. You have two opposing forces. When negotiating a turn remember to do things in sequence to avoid having opposing forces acting against each other.

(a) Brake – adjust entry speed

(b) Turn – Late apex, shuffle steer, slow hands

(c) Accelerate – Smoothly when vehicle is straight

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OHD 26 (Oversteer Illustration)

4. Oversteer simply means the rear tires exceed the limit of cohesion and the rear of the vehicle skids towards outside of turn.

   a) This condition is commonly referred to as being crossed up.

   b) Three basic reasons for understeer.

      1) Road/weather conditions – Rain, snow, ice, gravel, dirt, etc.

      2) Sudden or rough steering (fast hands)

      3) Rough application of throttle

   c) Normally control can be regained by smoothly letting off throttle and simultaneously counter steering or turning the front wheels towards outside of curve.

   d) Driver must react immediately and instinctively to oversteer situations. Once the slide has gone beyond 20 degrees efforts to regain control will be futile.

   e) As an emergency vehicle operator your success is dependent on proper turning movements. As you learn to apply techniques taught, your confidence and speed through turns will increase appreciably.

Conclusion: The key element to emergency response is not how fast you drive, but how efficient and consistent you are. When a driver understands such techniques as steering, braking and corner entry he/she can achieve a higher performance potential with less speed.

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